ROLE OF PROJECTILE FAILURE ON THE IMPACT FLASH. C. M. Ernst[1], O. S. Barnouin[1], and P. H. Schultz[2], [1]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723 (carolyn.ernst@jhuapl.edu), [2]Department of Geological Sciences, Brown University, Providence, RI 02912.

Introduction: Characteristics of the impact flash are highly dependent on the initial impact conditions [e.g., 1-6]. Flash evolution provides a means to examine early-time impact processes, providing insights into the projectile-target coupling, the partitioning of energy, and the generation of melt. The effects of impact velocity, angle, and target porosity on the peak intensity and evolution of the spatially integrated impact flash have been documented in previous experimental studies of impacts into non-volatile, particulate targets [7-10]. High-speed imaging has been used to resolve spatially the radiating source and determine its location [10]. We performed a suite of experiments over a wider range of velocities to investigate the effects of velocity and projectile failure on the resulting flash.

Experimental setup: The NASA Ames Vertical Gun Range was used to perform hypervelocity impact experiments. Translucent Pyrex projectiles 6.35 mm in diameter impacted pumice powder targets under near-vacuum conditions (< 0.5 Torr) at angles of 90º (vertical) and 30º. Impact velocities ranged from 1.6 to 5.2 km/s. The predominantly silicate compositions of Pyrex and pumice minimize the production of atomic and molecular emissions in the visible wavelength range and enhance the generation of thermal emissions, which are of primary interest for this study. At the higher velocities investigated, the Pyrex projectiles undergo brittle failure on impact.

A photodiode with a spectral range of 350-1100 nm positioned above the target chamber recorded the visible and near-infrared light output with time resolutions of 20-100 ns (with the exception of the 30º impact at 4.63 km/s, which was at 1 μs resolution). The field of view of each photodiode was large enough to ensure that all radiating sources would remain observable over the recorded time interval.

Light Curve Observations: Velocity suites of light curves for 30º and 90º impacts are shown in Figure 1. The light curves generally exhibit three common components: (1) an early-time spike, (2) a broad intensity peak, and (3) a long decay signal. Each component represents the effect of multiple processes and depends on initial impact conditions. The impact angle affects the shape of the early-time transient crater, which in turn influences the exposure of the radiating source [10]. The intensity peak magnitude and timing are related to the horizontal or vertical components of velocity. The delayed rise to the intensity peak is primarily caused by the growth of the radiating source [10].

There is a systematic metamorphosis of the light curve across the velocity suites, with the delayed, broad peak decreasing in intensity and onset time with decreasing velocity. At 30º, a double early-time spike (the second spike is due to the impact of the decapitated projectile) gradually morphs into a single, broader spike that decreases in intensity until <2.79 km/s. At 90º, the initial spike also systematically decreases with velocity until <2.29 km/s. At both angles, the lowest observed velocities generate very different looking light curves.

Interpretation: The decrease of the broad intensity peak is related to the decreasing temperature and extent of the thermal source. Figure 2 illustrates the relationship between the delayed intensity peak and the impact velocity. Above ~4 km/s (the region shaded grey), there is a consistent power-law relationship between peak intensity and velocity, consistent with those observed in previous experiments [1-5,7]. Below ~4 km/s, the trend levels off and the peak intensities of the different angles merge. Below ~3 km/s, the peak intensity again decreases with velocity.

Changes exhibited in the early-time spike feature are signs of changes in the interaction and coupling of the projectile and target. As impact velocity decreases, the projectile is less damaged, the projectile and target interact for a longer length of time, and friction becomes more important [e.g., 11]. In the case of the lowest velocities tested (~1.7 km/s) the Pyrex projectile does not fail completely at either impact angle, resulting in a different signal evolution. At these lower velocities, projectiles ablate and are not dispersed into the target (i.e., little or no fragmentation). At higher velocities, the projectile is broken into multiple hot fragments that radiate and scour across the transient crater floor. Planetary scale hypervelocity impacts into typical regolith-like substrates should generate long-lived thermal signals, the extent of which is strongly correlated to the strength of the projectile.

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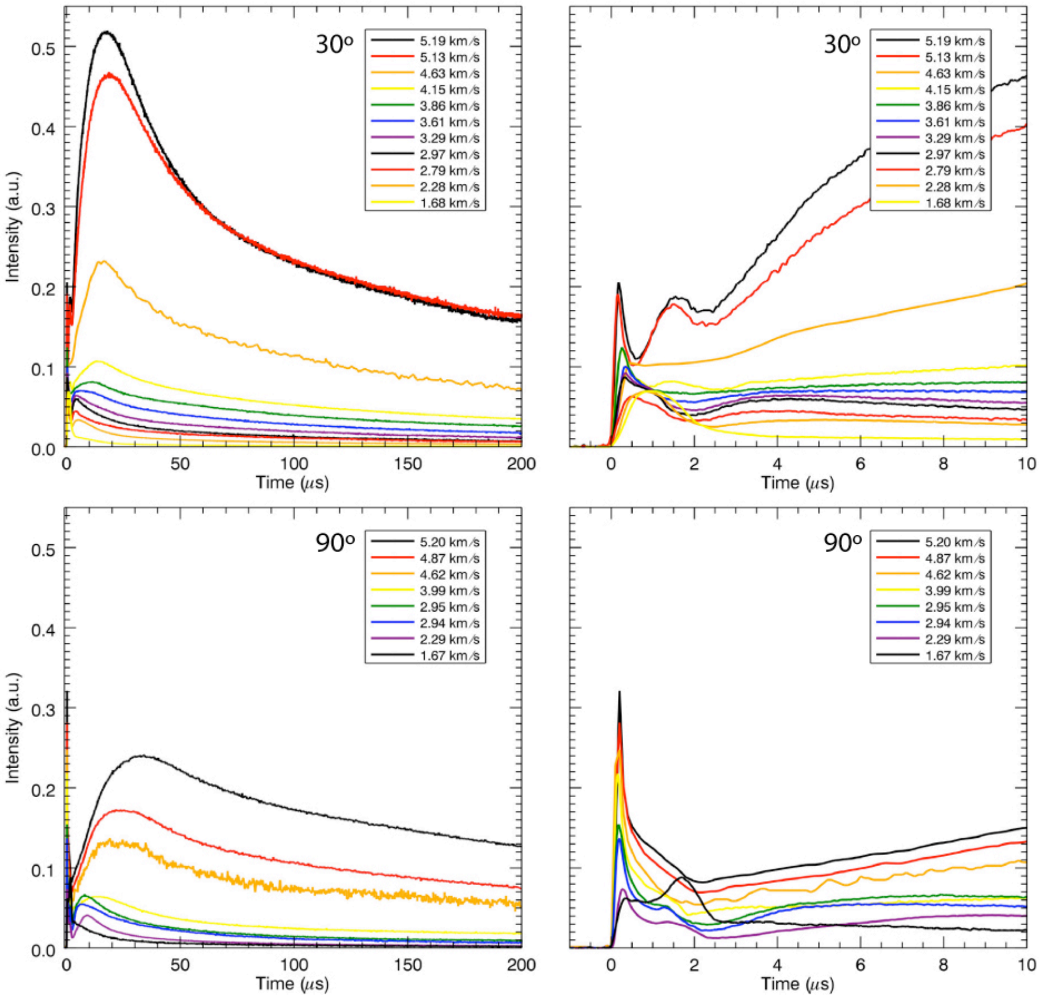

Figure 1. Impact flash intensity through time for impacts of 6.35-mm-diameter Pyrex projectiles into pumice powder targets at 30º (top) and 90º (bottom). The zoomed views on the right display the first 10 μs of the flashes shown on the left. By 1.68 km/s, the flash no longer exhibits the delayed intensity peak in the visible wavelength range that is so characteristic of the faster impacts. The impact at 30º and 4.63 km/s was recorded at lower time resolution than the others.

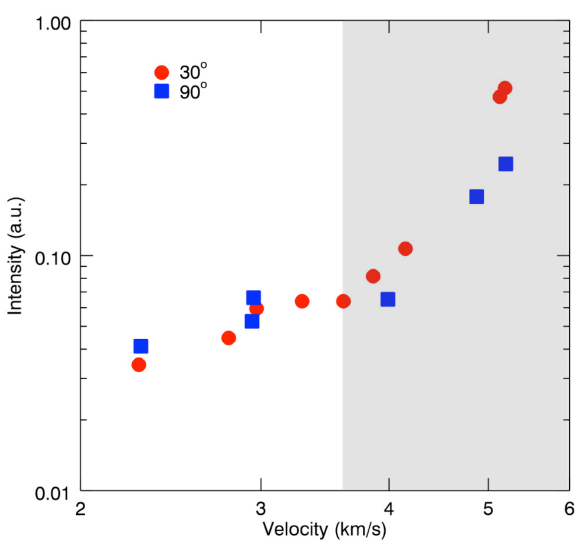

Figure 2. Peak intensity of the delayed thermal signal versus velocity for 90º and 30º impacts. Above ~4 km/s (shaded grey), there is a consistent power law relationship between peak intensity and velocity, as observed in previous experiments [1-5,7]. Below ~4 km/s, the trend levels off and the peak intensities of the different angles merge. Below ~3 km/s, the peak intensity again decreases with velocity.